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FIELD STUDY EVALUATION OF AN EXPERIMENTAL PHYSICAL FITNESS PROGRAM FOR USAF FIREFIGHTERS

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Under emergency conditions, firefighting demands extraordinary levels of physical effort in performing tasks under some of the most life threatening conditions. Success in performing these tasks depends on the firefighters physical fitness, particularly his/her cardiovascular endurance. Studies have shown that firefighters, both in the civilian and military sectors, are generally less fit than their age related sedentary American counterparts. This report describes a field study to evaluate the safety and effectiveness of an experimental physical conditioning program that could be prescribed on an individual basis. Special emphasis was placed on a conservative program for older, less fit firefighters who would be most susceptible to exercise-related injury.

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Executive Summary

A. OBJECTIVE

The objective of this study was field evaluation of a fitness conditioning program designed to meet the needs of individual USAF firefighters.

B. BACKGROUND

Under emergency conditions, firefighting demands extraordinary levels of physical effort in performing tasks under some of the most life threatening conditions. Success in performing these tasks depends on the firefighter's physical fitness, particularly his/her cardiovascular endurance. Paradoxically, studies have shown that firefighters, both in the civilian and military sectors, are generally less fit their age related sedentary American counterparts. Although firefighter's injury rates are among the highest of all occupational, heart attack remains the leading cause of death for firefighters on duty.

C. SCOPE

Although many exercise programs can effectively achieve strength and cardiovascular endurance objectives, few are appropriate for the on duty firefighter. This occupational group includes men and women, age 18 to 50+ years, may of whom are seriously overweight and underfit, and neither accustomed to nor particularly interested in exercise of any kind. Traditional programs incorporating either jogging or athletic game activities could be expected to produce an unacceptable rate of injury on the population. Additionally, if fitness is a critical requirement for the firefighter; it should not be left to chance; it must be incorporated into each duty day. Therefore, the designated program must at least be safe and effective in accomplishing the fitness objective.

D. METHODOLOGY

In addition to participating in the study to determine the fitness status of USAF firefighters, the fire Chiefs at four USAF bases (Grand Forks, Ellsworth, Plattsburgh, and Randolph) volunteered their departments' cooperation in a study to test the safety and effectiveness of an experimental conditioning program for improving firefighter fitness. The initial tests established fitness baselines; then detailed individualized training programs covering 16-week periods were prepared for each firefighter. Facilities, equipment, and duty time were provided for the participants who were directed to consider this training as a mandatory part of every workday.

E. TEST DESCRIPTION

Tests on aerobic capacity, muscular strength, muscular endurance, and percentage of body fat were performed. Tests and training prescriptions were repeated at 16-week intervals for 1 year. Paired t-tests for repeated measures and analysis for variance statistical techniques were used to evaluate the significance ($P<0.5$) of changes in fitness attributed to this experimental program.

F. RESULTS

The intent of this study was to establish a baseline fitness value for all firefighters and to provide each with an individualized exercise "prescription" designed to improve both cardiovascular and muscular fitness. The exercise regimens outlined in this training schedule were to be completed exactly as prescribed and at least one training session per duty day was mandatory. Firefighters were instructed in the use of daily logs provided in each exercise prescription notebook for the purpose of tracking the individuals adherence to the program.

G. CONCLUSIONS

The results of submaximal exercise test on a cycle ergometer to predict aerobic capacity on all firefighters assigned to four USAF bases confirmed earlier findings that USAF firefighters were below average in cardiovascular fitness; hydrostatic weighing to determine body density found that those men (75 percent) were also above average in body fat content.

H. RECOMMENDATIONS

To enhance the capabilities of USAF Fire Protection services minimal standards for aerobic capacity and muscular strength should be established as conditions of employment for USAF firefighters. Additionally, higher level of fitness, more commensurate with the strenuous tasks imposed on firefighters should be considered for future goals.

PREFACE

This report was prepared by USAF School of Aerospace Medicine (USAFSAM/VNC), Brooks AFB TX 78235, for the Air Force Engineering and Services Center, Engineering and Services Laboratory (HQ ASESC/RDCF), Tyndall Air Force Base, Florida 32403-6001. This work was sponsored by the US Air Force Engineering and Services Center (HQ AFESC). Mr Wade H. Grimm was the HQ AFESC/RDCF program manager. This report summarizes work accomplished between 10 Jun 1985 through 20 September 1986.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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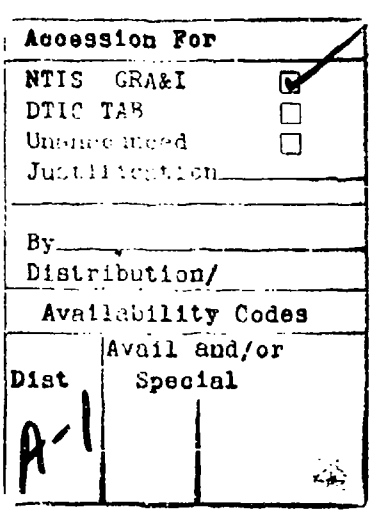

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INTRODUCTION

A. OBJECTIVE

The objective of this study was field evaluation of a fitness conditioning program designed to meet the needs of individual USAF firefighters.

B. BACKGROUND

Under emergency conditions, firefighting demands extraordinary levels of physical effort in performing tasks under some of the most life threatening conditions. Success in performing these tasks depends on the firefighter's physical fitness, particularly his/her cardiovascular endurance (Reference 17). Paradoxically, studies have shown that firefighters, both in the civilian and military sectors (Reference 17), ar generally less fit than their age related sedentary American counterparts (Reference 12). And, although firefighter's injury rates are among the highest of all occupational (References 20, 21, 22), heart attack remains the leading cause of death for firefighters on duty (Reference 24).

In a study to determine the fitness status of USAF firefighters, Myhre et al. (Reference 16) suggested that this lack of fitness was a serious, but not a hopeless problem. These firefighters' working environment (i.e., the station area and normal duty schedule) was ideally suited for incorporating a sound fitness development program and they recommended that this be given a high priority. It was further indicated that, although the firefighters' attention to fitness should be encouraged as a health benefit, it should be demanded as a performance requirement. Indeed, early attempts to implement this requirement were given in USAF Regulation 92-1 as follows:

"All firefighters must participate in a job-related physical fitness exercise program in the fire station area. These physical fitness programs should be developed with the advice of qualified physical fitness persons."[1]

Fire Chiefs were generally left to their own resources for dealing with this regulation and they did so with varying degrees of success. However, recent advances in physiological research have clearly identified the critical exercise criteria which constitute a training program which will safely and effectively improve and maintain cardiovascular fitness. Myhre (Reference 13) used these criteria in designing an efficient and economical program specifically for USAF firefighters Although that program incorporated the essential elements for achieving fitness objectives, it was deemed necessary to evaluate it under practical field conditions before USAF implementation. This paper describes that study.

1 (Taken from AFR 92-1(C1), 3 June 1983, Chapter 2)

C. SCOPE

Although many exercise programs can effectively achieve strength and cardiovascular endurance objectives, few are appropriate for the on duty firefighter. This occupational group includes men and women, age 18 to 50+ years, many of whom are seriously overweight and underfit, and neither accustomed to nor particularly interested in exercise of any kind (Reference 16). Traditional programs incorporating either jogging or athletic game activities could be expected to produce an unacceptable rate of injury in this population. Aside from the obvious requirement for rapid response which limits the exercising firefighter to the station area, climatic conditions can be expected to impose severe restrictions on outside activities for extended periods. Consequently, the firefighter might not be able to accomplish the fitness objective. Furthermore, if fitness is a critical requirement for the firefighter (Reference 16); it should not be left to chance; it must be incorporated into each duty day. Therefore, the designated program must at least be safe and effective in accomplishing the fitness objective.

This report describes a field study to evaluate the safety and effectiveness of an experimental physical conditioning program that could be prescribed on an individual basis. Special emphasis was placed on a conservative program for older, less fit firefighters who would be most susceptible to exercise-related injury.

SECTION II

METHODS AND PROCEDURES

A. METHOD

In addition to participating in the study to determine the fitness status of USAF firefighters (Reference 16), the fire Chiefs at four USAF Bases (Grand Forks, Ellsworth, Plattsburgh, and Randolph) volunteered their departments' cooperation in a study to test the safety and effectiveness of an experimental conditioning program for improving firefighter fitness. The initial tests established fitness baselines; then detailed individualized training programs covering 16-week periods were prepared for each firefighter. Facilities, equipment, and duty time were provided for the participants who were directed to consider this training as a mandatory part of every workday. Tests and training prescriptions were repeated at 16-week intervals for 1 year. Paired t-tests for repeated measures and analysis for variance statistical techniques were used to evaluate the significance ($P<0.05$) of changes in fitness attributed to this experimental program.

B. PROCEDURES (Fitness Evaluation)

Initial tests to determine individual fitness levels and exercise capabilities at the onset of this study included the following:

1. Aerobic Capacity.

Tests for predicting aerobic capacity ($\dot{V}O_2$ max) were performed in duplicate, i.e., on separate days, and always in the early morning (0530-0930 hrs) on subjects who had arrived at the station laboratory without breakfast and following a good night's sleep. All subjects wore shorts and shoes; female subjects wore blouses or halter tops. Room temperature was maintained at a comfortable level for exercise (65-80°F), and relatively free from noise and other distractions.

The subject was fitted with a chest lead cardiotachometer (Exersentry) and, after adjusting the cycle's saddle to the appropriate height for efficient pedaling, permitted to rest for 2 to 5 minutes in the seated position. The subject's preexercise heart rate (HR) was recorded and the exercise test began with the subject pedaling the cycle ergometer (Monark 868) to the rhythm of a metronome (50 rpm). The first three minutes were used to adjust the workload to a level which would result in a steady-state HR of between 130 and 155 beats per minute (bpm) during the 4th-6th minutes at that load. Thus, if the load needed no adjustment from the onset, the test would

between 45-60 seconds of each minute and the average of minutes 4-6 at the final load was used to predict VO_2 max from the Astrand-Rhyming nomogram with appropriate age corrections (Reference 2,3).

2. Muscular Strength.

Muscular strength was determined from the maximum weight lifted for a single repetition in each of the following standard lifting positions: Bench press, legpress, curl, and upright rowing. These tests were performed on either a Universal Gym or free weights, whichever were available at the station being studied.

3. Muscular Endurance.

Muscular endurance for a specific muscle group was determined according to YMCA/YWCA procedures for bench press repetitions. The subject performed a standard bench press repetitively in time with a metronome set at 60 bpm; the weight 80 and 35 pounds for men and women, respectively, was lifted, from the chest to full extension on the first beat, lowered to the chest on the second beat, and repeated in this fashion until the subject could no longer keep up with the metronome. Scoring was done by total number of repetitions completed.

4. Percentage of Body Fat.

Percentage of body fat was calculated from body density in a quiet swimming pool according to Myhre and Kessler (Reference 15) and, on some occasions, by measures of body volume according to Allen (Reference 1). All measures were corrected for residual volume determined by the nitrogen dilution technique (Reference 18) and body fat was calculated from body density according to Brozek et al. (Reference 5) using the following formula: %Fat = [(4.570/Body density) - 4.142] 100.

C. PROCEDURES (Individualized Training Programs)

The careful evaluation of each firefighter's fitness and physical capabilities at the onset provided the information necessary to construct a detailed training program which was tailored for the individual. These programs, designed to improve both muscular strength and cardiovascular endurance, are described (Reference 13).

The firefighters were instructed to follow these programs exactly, with at least three workouts per week for 16 weeks. At the end of that time, all fitness tests were repeated and new training programs were individually prepared. This was repeated for each 16-week period throughout the year of this study.

SECTION III

RESULTS

The intent of this study was to establish a baseline fitness value for all firefighters and to provide each with an individualized exercise "prescription" designed to improve both cardiovascular and muscular fitness. The exercise regimens outlined in this training schedule were to be completed exactly as prescribed and at least one training session per duty day was mandatory. Firefighters were instructed in the use of daily logs provided in each exercise prescription notebook for the purpose of tracking the individual's adherence to the program. The training program was prepared for a 16 week period and it was planned to observe changes in fitness, if any at regular intervals (4 months) over a 1-year period. However, it was quickly realized that attempts to follow such a plan with USAF firefighters would not succeed because it was impossible to retest every firefighter as scheduled. In addition to problems related to normal turnover of personnel, a significant number of the remaining firefighters were unavailable at each at each of the retest sessions. With these uncontrollable conditions, treatment of the collected data became complicated. In an effort to deal with this, the results of the training study will be presented in three general categories:

- Department Fitness: The overall condition of the department may be evaluated by presenting the results of all available members at the time of each test. Ignoring the unavailability of some participants for one or more of the retest sessions, and the few instances where new firefighters were brought on board between test sessions, these results summarize the general changes in department fitness which occurred while the fitness conditioning program was mandatory.

- Test-Retest: Those firefighters who remained in the department for the entire year were tested at both the beginning and the end of that period.

- Participant-Nonparticipant: Although the program was mandatory, it would have been naive to believe that every firefighter would accept this charge; consequently, it would be unfair to evaluate a conditioning program based on results from those who never participated in it. Except for the benefit gained from analyzing general adherence to orders and duty, the nonparticipant should be considered as a control. The nonparticipants' results could be used as a reference for what can be expected from fitness tests given to people at 4-month intervals while remaining relatively sedentary for up to 1 year. In this way, the nonparticipant provided a service to this study.

A. INITIAL FITNESS STATUS

Physical characteristics of the USAF firefighters participating in the initial phase of this study are presented in Table 1. The values here represent the condition existing at each of the four departments at the start of this effort, i.e., before to entering into a formal physical conditioning program.

TABLE 1: PHYSICAL CHARACTERISTICS OF USAF FIREFIGHTERS ASSIGNED TO FOUR USAF BASES PRIOR TO BEGINNING A PHYSICAL CONDITIONING PROGRAM. (MEAN + S.D.)

Age yrs	Height in	Weight lbs	Body Fat %	$\dot{V}C_2$ Max ml/kg/min
29.6 ±9.3 (n=203)	70.0 ±2.5 (n=203)	177.9 ±25.3 (n=203)	20.4 ±6.7 (n=148*)	39.0 ±9.3 (n=203)

Table 1 shows that 203 firefighters were tested at the start of this study; only those who were on leave or physically disabled were exempt. The mean values presented here suggest that the average USAF firefighter is a male, 29.6 years old, 5 feet 10 inches tall, weighs 177.7 pounds of which 20.4 percent is fat, with a $\dot{V}O_2$ max of 39.0 ml/kg/min. Compared with values appearing in the literature for normal sedentary men, this "average" USAF firefighter is above average in fatness (20.4 vs 15.3 percent, Reference 15) and below average in fitness ($\dot{V}O_2$ max = 39.0 vs 45.4 ml/kg/min) as suggested in Table 2.

The general decline in fitness with advancing years is illustrated in Table 3 where firefighters are classified according to the following age groups: 18-29, 30-39, and 40-59 years. Again, compared with values from the literature (summarized in Table 2), these firefighters were generally less fit than their counterparts of the same age in a sedentary American population.

TABLE 2: MAXIMAL CARDIAC FUNCTION IN SEDENTARY NORMAL MEN AND WOMEN (MEAN + S.E.) (Reference 12)

Age Group (Years)	$\dot{V}O_2$ Max (ml/kg/min) N	Men	N	Women	Heart rate max (bpm) Men	Women
20-29	6	45.4 ±4.2	9	37.9 ±4.2	196	198
30-39	7	41.8 ±5.7	33	28.3 ±3.4	189	184
40-49	35	37.7 ±5.6	39	25.9 ±3.3	181	179
50-59	28	34.8 ±6.1	22	24.7 ±2.8	172	177
60-75	22	28.0 ±6.9	1	18.7----	160	160

*An unusual fear of the water precluded the participation of all firefighters in this measure.

The general decline in fitness with advancing years is illustrated in Table 3 where firefighters are classified according to the following age groups: 18-29, 30-39, and 40-59 years. Again, compared with values from the literature (summarized in Table 2), these firefighters were generally less fit than their counterparts of the same age in a sedentary American population.

TABLE 3. AGE-RELATED PHYSICAL CHARACTERISTICS OF USAF FIREFIGHTERS ASSIGNED TO FOUR USAF BASES BEFORE TO BEGINNING A PHYSICAL CONDITIONING PROGRAM. (MEAN + S. D.)

Age yrs	Height inches	Weight lbs	Body Fat %	$\dot{V}O_2$max ml/kg/min
18-29	70.2 ±2.4 (n=114)	171.1 ±22.8 (n=114)	17.6 ±5.8 (n=87)	43.2 ±8.3 (n=114)
30-39	70.0 ±2.7 (n=58)	185.2 ±27.0 (n=58)	22.9 ±5.9 (n=42)	35.1 ±7.6 (n=58)
40-59	69.3 ±2.4 (n=29)	189.1 ±23.7 (n=29)	27.4 ±4.5 (n=19)	30.1 ±6.0 (n=29)

Strength data are not easily compared with normal populations, but the values observed for the firefighters in this study will serve as a basis for the future work. Thus, the data presented in Table 4 can be used as reference for strength levels typical of USAF firefighters.

TABLE 4. SUMMARY OF OBSERVATIONS OF DEPARTMENT FITNESS STATUS AT THE BEGINNING AND AT THE END OF A 12 MONTH EXPERIMENTAL CONDITIONING PROGRAM. (MEAN + S.D.)

	Start	12 Months	Difference	%Change
Body Weight,kg	80.6 ±11.4 (n=203)	81.2 ±10.7 (n=213)	+0.6	+0.8
$\dot{V}O_2$max,ml/kg/m	39.0 ±9.3 (n=203)	44.3 ±10.2 (n=213)	+5.3	+13.6*
Body Fat, %	20.4 ±6.7 (n=148)	15.1 ±7.1 (n=119)	-5.3	-26.0*
Bench Press, lbs	156.6 ±36.8 (n=133)	169.4 ±39.3 (n=128)	+12.8	+8.2*
Leg Press, lbs	353.7 ±72.8 (n=83)	468.8 ±103.8 (n=87)	+115.1	+32.5*
Curl, lbs	83.9 ±15.3 (n=134)	92.3 ±16.6 (n=127)	+8.4	+10.0*
Row, lbs	94.4 ±16.1 (n=134)	103.2 ±18.6 (n=127)	+8.8	+9.3*
80# Bench, no.	24.0 ±11.7 (n=136)	26.0 ±9.8 (n=125)	+2.0	+8.3*

*Difference is statistically significant at $p<.05$

B. TRAINING EFFECTS

As described previously, following the collection of baseline data, each firefighter was provided with a personalized exercise prescription designed to improve cardiovascular and muscular fitness. The effects of this mandatory program are summarized in the tables that follow.

- Departmental fitness responses to the training program are summarized in Table 4. Although all the firefighter's tested were not full participants in the training program, the effect of that program on the overall fitness status of the Department is represented by these data. Although body weight remained unchanged during the 12-month training program, percent body fat decreased significantly. Most importantly, $\dot{V}O_2$ max increased from 39.0 ml/kg/min to 44.3 ml/kg/min, an increase of almost 14 percent. It is also noted that increases of 8 to 33 percent in muscular strength were associated with the training program.

- Test-retest responses to the training program are presented in Table 5. In this analysis, only the firefighters who were present for testing at both the initial and 12-month test sessions were included. Consequently, these people were in the mandatory program for a full year and the results of the 12-month tests suggest a greater improvement in $\dot{V}O_2$ max while other values were very similar to those observed for the entire Department (see Table 3). Again the 16.7 percent average improvement in VO_2 max represents everyone tested, whether or not he participated fully in the training program.

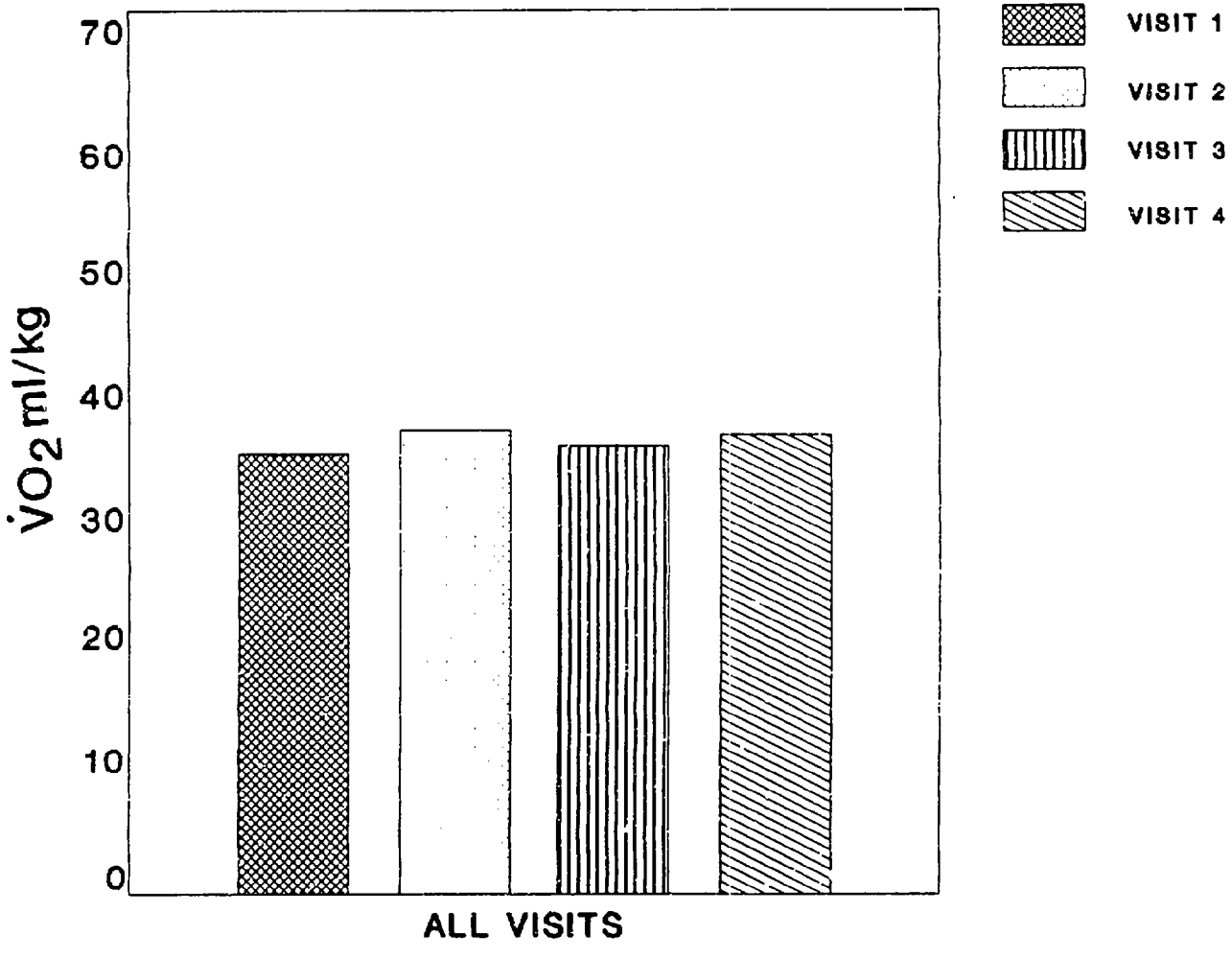
TABLE 5. SUMMARY OF THE EFFECTS OF AN EXPERIMENTAL CONDITIONING PROGRAM ON PHYSICAL CHARACTERISTICS AND FITNESS MEASURES OBSERVED IN THE SAME USAF MALE FIREFIGHTERS AT THE BEGINNING AND AGAIN AT THE END OF 12 MONTHS INVOLVEMENT IN THE PROGRAM. (Mean Values)

	N	Start	12 Months	SE(diff)	Difference	%Change
Body Weight, kg	123	82.16	82.30	0.38	+0.04	0.0
$\dot{V}O_2$ max, ml/kg/min	123	37.7	43.9	0.7	+6.3	+16.7*
Body Fat, %	53	21.5	15.5	0.6	-6.0	-27.9*
Bench Press, lbs	71	155.7	165.6	2.7	+9.9	+6.4
Leg Press, lbs	45	343.1	462.8	15.9	+119.7	+34.9*
Curl, lbs	70	84.0	92.1	1.5	+8.1	+9.6*
Row, lbs	69	95.0	104.3	1.6	+9.3	+9.8*
80#, reps	58	25.4	25.7	1.1	+0.3	+1.2

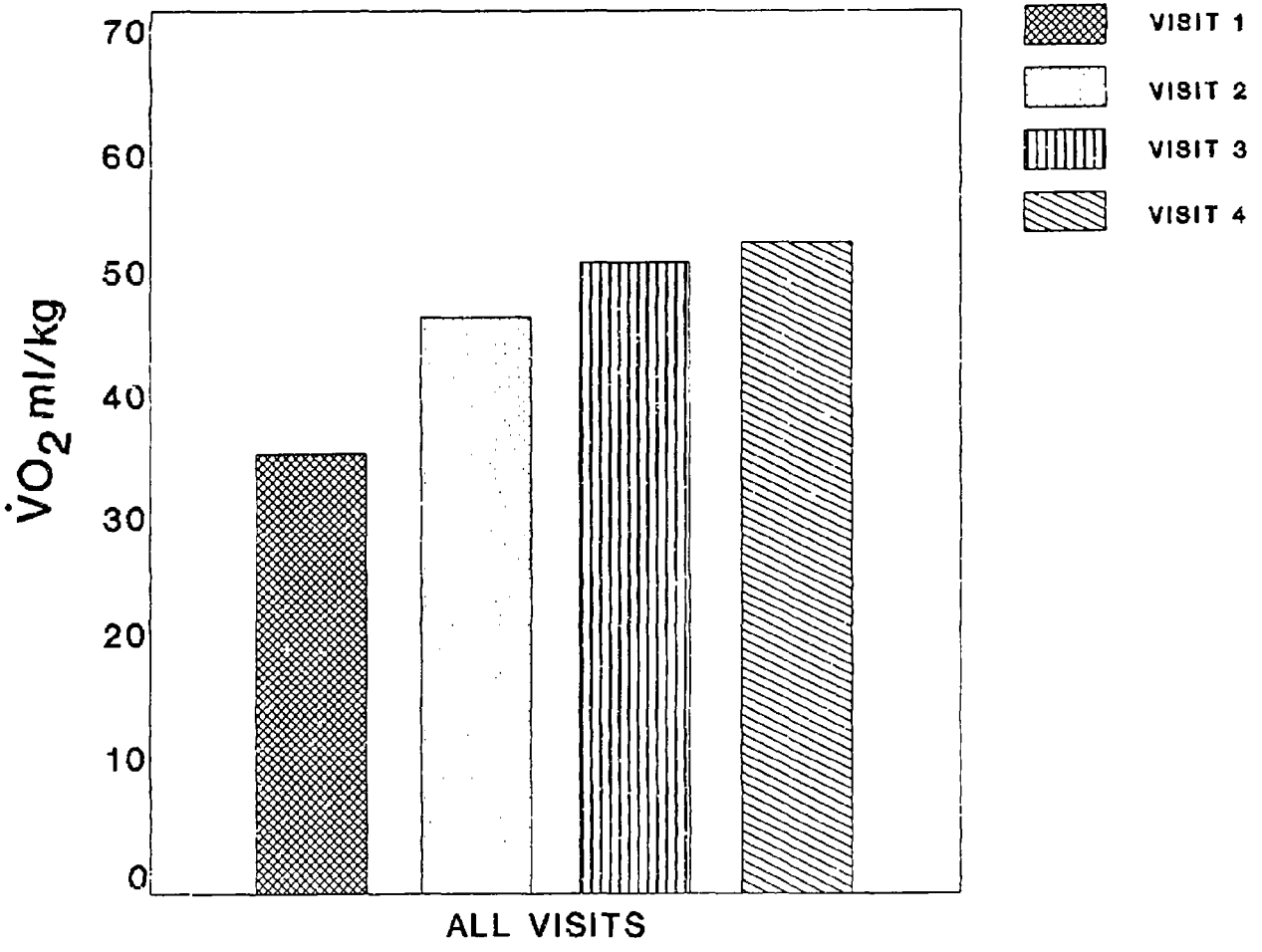
*Difference is statistically significant at $p<.05$

- Participant-nonparticipant responses to the cycle ergometer training program are presented in Figures 1 & 2. These results are most appropriate in evaluating the effectiveness of the program because they make a distinction between those who fully participated in the program (i.e., these participants followed each Department Chief's directive that the program was indeed mandatory) and those who did not. In these figures, the nonparticipant is defined as the individual who participated in the training regimen less than once a week; the full participant followed the prescribed program more than twice a week. The nonparticipant (Figure 1) showed absolutely no change in $\dot{V}O_2$ max during the one year period while the full participants (Figure 2) improved an average of 35 percent during the same period. Among the firefighters included in this subgroup, i.e., those involved in the program for the entire year, 63 percent were less than full participants. Stated another way, when presented with a duty order, only 37 percent complied and 26 percent frankly ignored the Chief's directive.

THE RESULTS OF MEASURES OF AEROBIC CAPACITY, REPEATED AT 4-MONTH INTERVALS, IN USAF MALE FIREFIGHTERS WHO DID NOT PARTICIPATE IN THEIR DEPARTMENTS STRUCTURED PHYSICAL CONDITIONING PROGRAM (M.V.)



THE RESULTS OF MEASURES OF AEROBIC CAPACITY, REPEATED AT 4-MONTH INTERVALS, IN USAF MALE FIREFIGHTERS WHERE FULL PARTICIPANTS PARTICIPATED IN THEIR DEPARTMENTS STRUCTURED PHYSICAL CONDITIONING (M.V.)



SECTION IV

DISCUSSION

The results of this study confirm the effectiveness of this program for improving the cardiovascular endurance of USAF firefighters. During the 12-month study period, the 35 percent improvement in the participant's aerobic capacity was remarkable and its effect on firefighter job performance and morale was even more encouraging (see Appendix A; letter from Chief Van Kirk). Although the absolute magnitude of this seemingly incredible rate of improvement may be questioned in light of the inherent limitations of a predictive measure, i.e., cardiovascular responses to submaximal exercise used here to estimate aerobic capacity as opposed to determining it by means of indirect calorimetry during exhausting treadmill exercise, the overall success of this training program was unequivocal. However, it was not without problems.

At the onset of this study all firefighters were briefed concerning the objectives of this program. First, they were advised that regular participation in this specialized program would be consistent with the most authoritative medical guidelines for improving cardiovascular health and lessening the risk of a disabling heart attack; thus, the individual firefighter would be the primary beneficiary of this program. Second, the firefighters were shown that particip tion in this program would significantly improve their ability to perform strenuous physical work for sustained periods without fatigue; consequently, they would become more effective in emergency situations and their ability to protect life and property would be greatly enhanced. It was discouraging to find that neither improved performance outcomes were adequate to motivate 63 percent of the firefighters who decided not to participate in this program.

The average firefighter seems resistant to programs designed to improve his/her cardiovascular health, fitness, and work performance. From this experience it can be estimated that if an effective program such as this were provided for all USAF firefighters under conditions by which the Fire Chief directs each firefighter to include it in his regular daily duties (i.e., exercise for 20-30 minutes each work shift which usually means only 3 days per week), more than 60 percent of them will find ways to avoid it most of the time and about 26 percent will ignore it. It appears that, under these circumstances, the Fire Chief's order may not necessarily move his employees to act. Rather, each firefighter makes his/her own decision whether or not to comply with an administrative related to a mandatory fitness conditioning program.

In addition to being effective, this fitness conditioning program was safe for its participants. Of a total of 357 firefighters who were tested at least once, (more than 200 of them were tested 8 times and were involved in the 12-month conditioning program) not a single injury occurred that could be attributed to either the cycle ergometer tests or the conditioning exercises. Such an extraordinary safety record could not have been achieved if activities such as jogging, aerobic dance, athletic games, or other dynamic weight-bearing exercises had been selected as the core of this program.

The improvement observed in the participating firefighter's aerobic capacity during the course of this program was encouraging to these investigators, but it could have been expected to be less impressive to professional firefighters concerned with its practical effects. However, in this case the measurable improvement in performance of a standard search and rescue exercise and the effect of this program on general firefighting ability was even more dramatic. For example, in one department which maintains a reciprocal aid agreement with nearby major city civilian fire departments, it was common knowledge that a firefighter working long enough to empty a SCBA cylinder would need a rest. During a large fire which occurred near the end of the 12-month conditioning program at the airbase it was found that USAF firefighters could work nonstop and those who had completed the program emptied as many as 10 consecutive air cylinders while their civilian counterparts were in the words of the Fire Chief, "...lying in the ditches after emptying one tank!" Further support for the practical effects of this conditioning program on the fire department as a whole is given in a letter from one of the participating Fire Chiefs and included in Appendix A.

During this study, it became evident that, although the program was highly effective in improving cardiovascular endurance, it was also labor-intensive. It required a one-on-one dedication of a research physiologist to properly conduct the tests and then to prepare each individual exercise prescription schedule. Although this was an acceptable arrangement for a research study, it would be impractical to recommend that this be followed for each of 153 USAF bases, especially considering that these tests and program preparations should be offered at 4 month intervals. Thus, it was deemed necessary to automate the entire program so that it could be safely and accurately conducted by Fire Department personnel. Physiological criteria were converted to algorithms which could be used to guide the layperson in test administration and the calculation of the results. Computer programmers were subsequently guided in the use of these algorithms in preparing the appropriate software package to further assist in the administration of the program. The final product, therefore, consists of a computer software package and an instruction manual, will facilitate the accurate administration of this program and assuring that it will be consistent throughout the USAF. General instructions in the administration of this fitness program are provided (Reference 13).

The fitness level, particularly the aerobic capacity, of the average USAF firefighter must be improved. To what level, is a debatable question because not every firefighter will be expected to perform the most strenuous firefighting tasks--or will they?. Setting a fitness requirement for firefighters is a sensitive issue, and it certainly cannot be resolved without further research to support top level negotiations between management and labor. However, it is known that success in performing certain critical tasks is directly related to fitness. For example, (Reference 17) the aerobic capacity of the average USAF firefighter is 39ml/kg/min and requires an average of 7 min to complete a standard search and rescue exercise. A highly fit firefighter (i.e., $\dot{V}O_2$ max of 64 ml/kg/min) can do this job in 1 min 24 sec. Put another way, the less fit firefighter is 400 percent slower in performing this important lifesaving exercise. It would be nice if all firefighters given optimal training, could achieve a $\dot{V}O_2$ max of 64 ml/kg/min, but they can not; hereditary limitations and the physiological

effects of aging are two reasons why such a goal would be impractical. However, in dealing with the question of what level of aerobic capacity should be considered as a minimum for employment as a firefighter, one would be hard pressed to recommend anything less than at least the average for a sedentary American. As whether such a standard would be attainable, and therefore fair for those who are now below it, it should be pointed out that the most common reasons for low aerobic capacity in healthy men and women are (1) lack of regular physical activity, and (2), overweight or obesity. Thus, faithful adherence to an appropriate exercise and/or weight loss program should allow most firefighters to make steady progress towards the goal of average aerobic capacity.*

To more specifically address the problem of selecting minimal standards, it is felt that a great deal could be achieved by a first step conservative approach requiring that all firefighters achieve a level reported as average for a normal population of sedentary male Americans. Although these values in the literature are not always in agreement, with differences due in part to varying methods for selecting a "normal" population sample, the values suggested here are sufficiently close to those reported by several investigators (References 2, 7, 12, 19) to merit their selection for this purpose. To be sure, citizens with mere average levels of aerobic capacity are not expected to engage in the physically demanding tasks of firefighting; all the more reason why the selection of these values as minimal standards should be beyond reproach. In addition, selection of such modest minimal standards should preclude the demand that those who fail should be offered the opportunity to be tested by the more valid (and more dangerous and expensive as well) exhausting treadmill exercise protocol. Therefore, the standards recommended in Section V are to be applied to the results of the cycle ergometer tests described by Myhre (Reference 13).

*Serious medical problems may preclude such progress for some and such cases should be handled with medical guidance on an individual basis.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The results of submaximal exercise tests on a cycle ergometer to predict aerobic capacity on all firefighters (n=203) assigned to four USAF bases confirmed earlier findings (Reference 13) that USAF firefighters were below average in cardiovascular fitness; hydrostatic weighing to determine body density found that these men (n=148) were also above average in body fat content. Following initial tests for baselines values, the firefighters were provided with individualized fitness training prescriptions to improve aerobic capacity and all tests repeated at 4 month intervals to check their progress. During a 12 month period, overall firefighter aerobic improved an average of 14 percent. However, this level of improvement reflects the results of all firefighters tested, whether or not they became active participants in the conditioning program. In spite of the Fire Chief's directive that this program was mandatory, 63 percent of those studied chose to avoid regular participation in it. In fact, 26 percent of the firefighters included in this study did not participate in the program at all and they showed a 0 percent improvement in aerobic capacity over the 12 month period. Thirty-seven percent were full participants and their predicted aerobic capacity increased an average of 35 percent for the same period.

This experimental program for improving cardiovascular fitness in USAF firefighters was found to be:

1. Safe: Not a single injury attributed to either the tests or the training exercise on the cycle ergometer over a 12 month period.

2. Effective: Improvement in cardiovascular endurance and in performance of strenuous physical tasks was both significant and remarkable.

3. Efficient: The conditioning program required only 30 minutes per day each duty day (i.e., 3 days/week).

4. Economical: Total cost for 4 cycle ergometers, sufficient for an average 60 person fire station, was less than $2,000 and this equipment has an expected useful life of more than 10 years.

5. Practical: The entire program can be conducted within the fire station; relatively little space is required and it can be administered by the Fire Chief without the need for outside specialists.

6. Medically Sound: The physiological principles incorporated in this program are understood by the medical community and are consistent with the latest research findings for developing individualized training regimens for healthy adults.

The fitness program described by Myhre (Reference 13), was designed to be implemented on an individual basis and it is considerably less stressful than the physical demands imposed by most firefighting tasks. Consequently, people who have been medically cleared for active duty should not require further medical evaluation before entering this program. However, although the safeguards incorporated by the individualized nature of this program are consistent with those recommended by Fox et al (Reference 9) and by the American Heart Association (References 6&8), it is always prudent that people unaccustomed to regular exercise especially those over 35 years of age and with known risk factors for cardiovascular disease, consult their personal physician before entering any new vigorous exercise regimen.

In conclusion, there is an urgent need to improve the physical fitness level of the average USAF firefighter. The exercise program developed for and evaluated by this experimental study is both safe and effective in accomplishing this objective. However, in spite of the effectiveness and the safety demonstrated by this program, the results of this study offer little hope that all USAF firefighters, particularly the least fit and poorest performers, will gainfully participate in any fitness improvement program mandated at the fire chief level or below. Without support from the highest levels of management, the implementation of any fitness improvement program for USAF firefighters would be an exercise in futility.

B. RECOMMENDATIONS

To enhance the capabilities of USAF Fire Protection services, and in particular to protect the health and safety of both potential fire victims and firefighters, the following recommendations are presented for consideration:

1. Minimal standards for aerobic capacity and muscular strength should be established as conditions of employment for USAF firefighters, and the first step in setting these standards should be an attempt to bring all existing firefighters at least up to the age adjusted average for the sedentary American male* population. These standards are summarized in Table 6.

2. Higher levels of fitness, more commensurate with the strenuous tasks imposed on firefighters should be considered for future goals. These more specific fitness standards should be supported by research evidence establishing the relationship between a given fitness level and physical performance capability for specific firefighting/emergency tasks (i.e., task relevence).

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*Firefighting and rescue tasks are no less demanding for the female than for the male firefighter. Therefore, it is appropriate that the physical requirements for this career field be nondiscriminatory with respect to sex.

TABLE 6. MINIMAL FITNESS STANDARDS FOR MALE AND FEMALE USAF FIREFIGHTERS

Age	VO_2 Max (ml/kg/min)	Bench Press (lbs)	Leg Press (lbs)	Curl (lbs)	Rowing (lbs)	80# Bench Press (repetitions)
19-29	46	160	380	85	95	24
30-39	42	155	370	80	90	22
40-49	40	150	360	75	85	20
50-59	38	145	350	70	80	18
60-65	34	140	340	70	80	16

3. Emergency rescue positions should be limited to those, regardless of age, who meet or exceed the fitness level requirements recommended for the 19-29 year old age group in Table 6.

4. The experimental program evaluated in this study, which can effectively improve and/or maintain physical strength and cardiovascular endurance, be implemented on a mandatory basis for all USAF firefighters.

5. This program should be reviewed and supported by the USAF Surgeon General and that it should be mandated by the Director of USAF Engineering and Services.

6. An Air Force pamphlet should be prepared to describe and to facilitate the implementation of this program. (Note: AFP 92-3, was published on 17 March, 1989)

7. This program should be implemented and then monitored for yearly evaluation. It is recommended that fitness test administrators during this period be restricted to individuals designated by the Chief of Air Force Fire Protection who will also designate the appropriate need-to-know individuals who will record and file these confidential data.

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APPENDIX A

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PHYSICAL FITNESS PROGRAM
(Observations)

The physical fitness program at Grand Forks AFB is over two years old and the results of the program have manifested themselves in many ways. Those who have taken part in the program and have accepted it as a fact of life within the parameters of the fire service, have gained the most from the program. Those who are performing physical fitness activities in a half-hearted manner and really don't apply themsevles, are receiving the least benefit.

The combined weight loss of 12 people totals over 350 pounds and the average of these individuals is 40 years of age. It would appear that the people who most needed a change in their physical condition were the most affected by the program if they participated earnestly. One individual with hypertension, and a known cardiac patient, reduced his resting pulse from 73 pbm to 52 pbm, is no longer on medication for hypertension, has lost 30 pounds, and ran a 26.2 mile marathon one year after beginning the physical fitness program at the age of 41 years.

Physical fitness efforts in this fire department are creating the most fundamental change we have witnessed in many years. It falls in line with the "wellness-movement" our country is experiencing now and may very well be the most significant movement we will experience in terms of improving our life styles in this country.

The physical conditioning program has aroused an awareness in the fire fighter that wasn't there before this program was started and it didn't occur overnight. In time, those in the program have developed a greater sense of self, more conscious of good health and individual growth. Most individuals eat better, drink less hard liquor, are turning of to smoking and are looking forward to a better quality of later life and a more vigorous one.

The physical conditioning program was not received without controversy and will probably continue to face resistance by those who prefer the sedentary life style. Those in the program, sweat hard before work or after work as a part of their daily routine, but as a result of their sweat, they function better during work. Now that management promotes the active life as a part of departmental policy, critics of the program usually make up the sedentary majority who resist the program. Any policy which offers change, and will continue to change as more and more individuals increasingly realize that the opportunity to strive for good health through physical conditioning and improved fitness is available to them and causes three things to happen. You increase self-esteem, lessen depression and tension and experience an increase

in the enjoyment of life itself, including relations with co-workers. Smoking has long been one of the traditions associated with fire service. Smoking has long been a tradition associated with male egos. It was stylish and a manly thing to do. We have discovered that one of the best ways to quit smoking is to begin an exercise program which is aerobic in nature. When you get your body going, and you start breathing deeply, you body tells you it's time to quit smoking, provided you have committed yourself to a physical conditioning program. In addition, when you carry your program outside the fire station, you begin to associate with different peer groups and this supports your efforts to quit smoking. Since the physical conditioning program was initiated at Grand Forks, 11 fire fighters have quit smoking, and two areas of common use within the fire station have been designated "no smoking" areas. Smoking is rapidly changing it's role within the fire station. Once considered to be a socially acceptable practice, is now becoming a less acceptable one and is now considered a well proven health hazard. Those who have taken the physical conditioning program seriously, have seized the opportunity to support themselves in their efforts to quit smoking. It seems they find it easier when they have vested interest. We know through studies that nonsmoking men and women live longer than mean nd women who smoke. These study estimates are by products. It's the quality of life after you quit smoking that has had the most significant impact on those that have quit here at Grand Forks.

Diets have changed significantly. Food served in the dining facility within the fire station has improved with the addition of an expanded salad bar. Fire fighters are eating more fruits, vegetables, cereals, and breads. They are order low calorie foods when available and are substituting more fish and poultry for red meats. Because of the restricted menu customarily served in fire department dining facilities, the selection and latitude is somewhat restrictive. Those foods prepared at home have also undergone changes in regard to avoiding saturated fats, and broiling instead of frying. Many more are using low calorie products and beverages. Since each individual has had a cholesterol count conducted (those in the original program) they have had the opportunity to consider the risk factor for coronary disease and many have taken steps in behavior modification to reduce the cholesterol count.

In the working environment, employees who exercise with dedication, and work up to that sweat, have less absenteeism, are stronger in their jobs, seem to be happier and more able to "get along", have less sick days, and appear to have more energy to do the work to be done. Those individuals who "work out" together have taken advantage of a change and are experiencing an opportunity to get to know and understand another part of each other. This opportunity to "get together" on the job and do something besides "the job" has helped each individual to better understand the the other person through a bond that has developed naturally through "working out" together.

Those actively involved in the program know they are better persons than they were before the program started. The know they are in better physical condition because their body shows it. They are stronger physically because they can do more work, it hurts less, and they generally feel better about their job and themselves. They know they are stronger mentally because they

are not affected by stress as easily as they were before dedicating themselves to the program. We have firefighters who are more fit than counterparts on half of their age. The physical conditioning program is a method by which older fire fighters can become more aware of their ability to perform physically and be more active. Stress and stress related illness is one of the major killers of fire fighters today. Any event that causes tension or surpasses the ability of an individual to adapt can be considered harmful stress. Stress is an everyday word in the fire service and it takes its toll. In addition to all the other benefits listed above with regard to aerobic exercise, the release of tension and the ability to cope with stress is one of the most satisfying. The comments of fire fighters actively involved in the physical conditioning program run the course from "exercise relaxes me" to "it hurts so good". The one common underlying denominator is that aerobic exercise is relaxing, it lowers blood pressure, reduces heart rate, helps asthmatics breathe, and helps you keep from getting sick as often as other not engaged in the program. Fir people handle stress better, and that's what's happening to those who have improved their fitness level here in this department. One of the most often observed characteristics of the increased level of fitness is the rate at which the pulse returns to normal after exercise. Those individuals actively in the program notice a very significant level in the "return to normal" heart rate. This stands to reason since aerobic exercise is in itself a form of stress, the more often your body recovers, so we are in effect training our bodies to recover from and conditioning it to respond to stressful situations.

Those who have quit smoking as a result of physical conditioning have also improved their life style by lowering the blood pressure by not smoking. In addition they have reduced their chances of heart attack and stroke significantly reduced the risk of lung cancer and emphysema. The physical conditioning program has raised the level of awareness in eating and drinking habits and acted as a stress relief mechanism.

Some individuals opposed the program and were critics from the very beginning. One side effect is that those people more prone to the sedentary life style may be forced as a matter of their choice to seek an alternative form of employment. Since the program has begun here at Grand Forks, two individuals have done just that. This choice exercise by such individuals serves to strengthen the physical conditioning program and increases the quality of the fire fighting force since newly hired employees are told from the initial stages of employment that physical conditioning program is mandatory, and will be part of their daily routine.

Such physical conditioning programs are viewed by the skeptics as fads. By those who have become involved in such a program and support them, they are viewed as a trend. Physical Conditioning and aerobic exercise is an essential element in the lies of fire fighters at Grand Forks AFB, and every effort should be made to ensure it becomes a part of every Air Force fire protection organization.

GEORGE R. VAN KIRK, GS-11, DAFT
Fire Chief